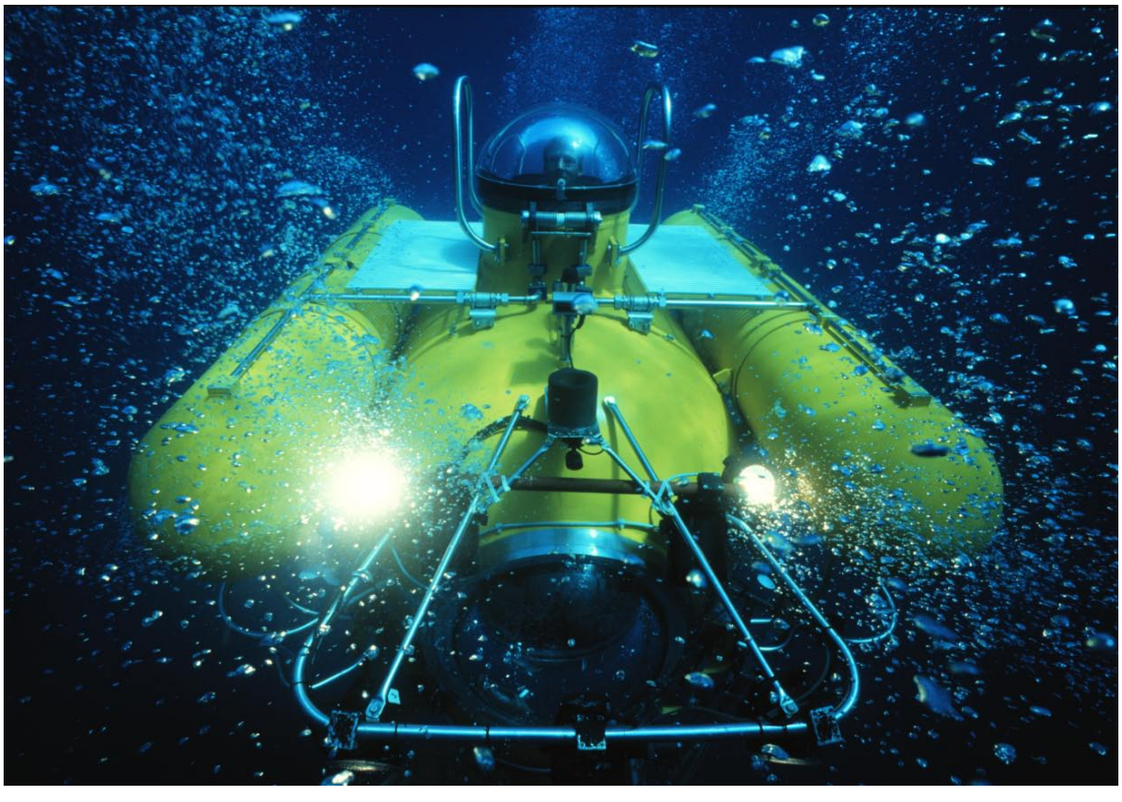
IFM-GEOMAR

Leibniz-Institut für Meereswissenschaften
an der Universität Kiel

IFM-GEOMAR Report 2006

From the Seafloor to the Atmosphere

- Marine Sciences at IFM-GEOMAR Kiel -



IFM-GEOMAR Report 2006

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Cover photo: Submersible JAGO diving in the Indian Ocean (Jürgen Schauer, IFM-GEOMAR).
Inner cover: s.a.

Preface

Three years after the merger of IfM and GEOMAR, the decision to merge the two institutes has proven to be a strategic and scientific success. The reputation and profile of IFM-GEOMAR has increased tremendously and has established Kiel as a major centre of marine sciences in Germany and Europe. One indicator of the success of the new institute is the so-called "DFG-ranking", published by the German Research Foundation (DFG). For the period 2002-2004, IFM-GEOMAR was by far the most successful non-university research institute in terms of DFG-project funding. An important milestone for the strategic development of the institute is represented by the positive funding decision for the excellence cluster "The Future Ocean". In this project, IFM-GEOMAR cooperates with six different faculties of the University of Kiel, the Kiel Institute for the World Economy and the Muthesius College of Fine Arts. The cluster, which has a budget of 36 Mio. Euros for a 5-year period, will cover a wide range of topics including chances and risks of the future ocean such as ocean acidification, marine resources and the consequences of climate change. Four of the 14 new junior research groups will be located at IFM-GEOMAR. The generous funding of "Future Ocean" will enable the creation of about 100 new high-profile jobs in Kiel.

Progress has also been made in the area of research infrastructure. The new Technology and Logistics Centre (TLC) of IFM-GEOMAR opened as the new central basis for the development and maintenance of instrumentation, as well as for the technical preparation of seagoing expeditions. The first large device that found its new home in the TLC is the submersible "Jago" the only manned research submersible in Germany. "Jago" was acquired by IFM-GEOMAR in January and provides an attractive platform for multidisciplinary marine research. In addition, the construction of a Remotely Operated Vehicle (ROV) with a diving capability of 6000m started recently. The ROV will be available for the marine research community in late 2007. Other large-scale facilities such as offshore mesokosms and an Autonomous

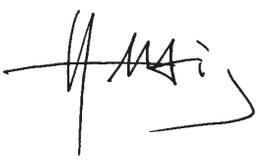
Underwater Vehicle (AUV) are also being developed.

On the scientific side, plans for a new collaborative research centre (SFB) on "Climate-Biogeochemistry Interactions in the Tropical Oceans" are well developed. The review of the pre-proposal was very encouraging and the on-site review and the funding decision are expected for 2007.

Overall, the developments in marine sciences in Kiel and particularly at IFM-GEOMAR have been extremely positive during the past year. Due to successful proposals and generous additional support by the State of Schleswig-Holstein, the institute now enjoys a solid foundation with which it can strive for continued excellence in marine research. We are confident that we can further strengthen our leadership position over the next few years in order to establish IFM-GEOMAR as a "National Centre for Marine Sciences" with high international visibility.

This report provides a short overview of the major developments and scientific highlights during the past year Detailed statistical information can be found in the appendices. I hope that you will enjoy reading the "IFM-GEOMAR Highlights 2006".

Kiel, October 2007



Prof. Peter M. Herzig
Director

The Sumatra subduction zone in the wake of the 2004/2005 megathrust events

The occurrence of the 26 December 2004 Mw 9.3 and the 28 March 2005 Mw 8.7 megathrust earthquakes shifted the international research focus to the Sumatra margin. In the wake of the devastating tsunami generated by the 2004 Sumatra-Andaman earthquake, a suite of geo-scientific data was acquired to help unravel the linkage between earthquake dynamics and margin segmentation. Geophysical investigations of the Sumatra margin were performed from October 2005 to March 2006 using RV SONNE. These investigations revealed that upper plate segmentation of the Sumatra trench system is manifested in varying modes of mass transfer. The margin segments to the northwest of the Investigator Fracture Zone (IFZ), which were affected by the 2004 and 2005 megathrust earthquakes, are subject to extensive surface erosion of the margin wedge. Oversteepening of the lower slope in response to elevated pore pressures and the subduction of pronounced seafloor topography leads to mass wasting processes here. Conversely, neotectonic formation of nascent accretionary thrust folds is limited to the sections of the deformation front southeast of the IFZ and documents the resumption of frontal sediment accretion in the wake of oceanic relief subduction. The distinction in modes of mass transfer from frontal accretion in the south (Fig. 2a) to surface erosion in the north (Fig. 2b) correlates to the increase in frontal slope angle (Fig 2 e-f).

The large-scale morphotectonic segmentation of the Sumatra trench system results from subduction of reactivated fracture zones and aseismic ridges of the Wharton Basin and is also reflected in its seismotectonic segmentation as most recently evidenced by the distinct rupture zones of the 2004-2005 earthquake couplet. Subduction of topographic relief on the lower plate and discontinuities in the geometry of the subduction zone modulate upper plate structure. In addition, geometry variations are closely linked to physical property changes. Heterogeneity in the physical properties of the forearc is associated with a strong lateral variability in age as well as crustal composition and architecture. The topography of the fracture zones represents tectonic segment boundaries and zones of anomalous crust with regards to density, crustal composition and thickness.

The extent of the 1797/1833, 1861/2004 and 2005 rupture zones shows an intriguing correlation to the segment boundaries (Fig. 1). The remarkable correspondence of the slip areas to the fracture zones suggests that earthquake rupture propagation may be inhibited across segment boundaries due to the variation in thrust geometry, material strength, fluid content and pre-stresses. Different sectors along the Sumatra trench show a strong variability in pore pressure, plate coupling and state of stress.

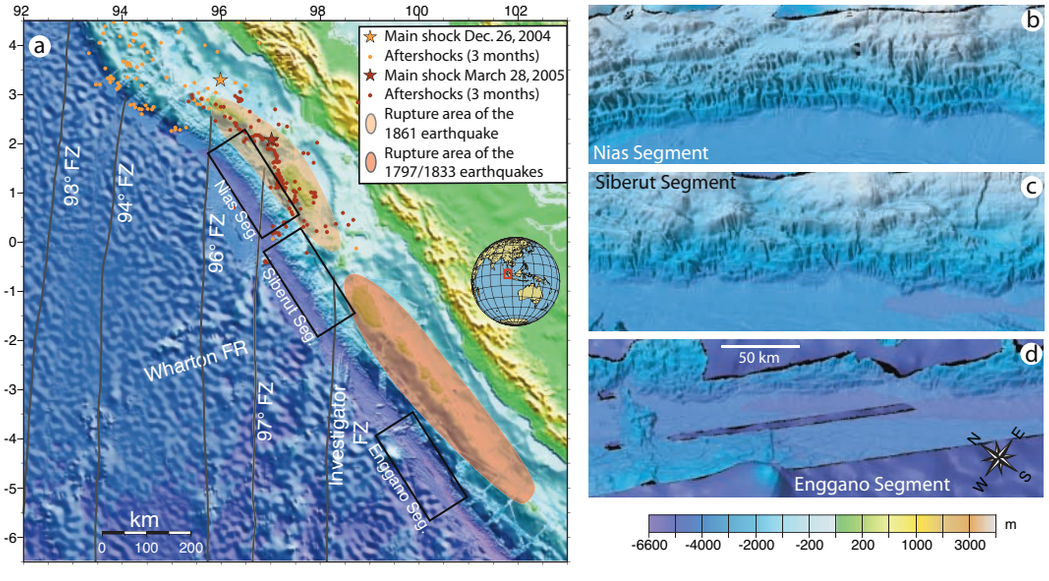


Fig. 1: a) Investigation area off the coast of Sumatra, main earth quakes are indicared by stars, aftershocks by dots, respectively. Rupture zones of historic earthquakes are shaded in brown/orange, black boxes indicate boundaries of detailed sea floor segements shown in Fig. 1 b-d.

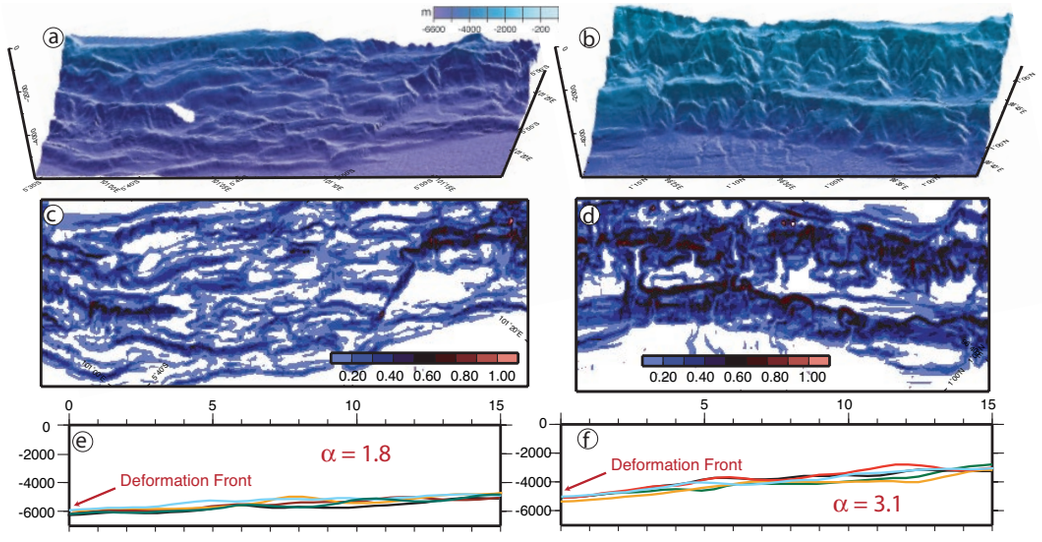


Fig. 2: a) southern, b) northern areas of investigation, their vertical structure(c) and d) and frontal slope (e) and f) as described in the text.

The aftershock distribution of the 2004 event shows a very sharp southern boundary at the prolongation of the 96°E FZ, implying that rupture did not jump across the anomaly to the stress-reduced adjacent segment. In the wake of the 2004 earthquake, however, the state of stress along the margin was appreciably altered: strain was released along the Andaman trench while the adjacent southern segment was brought closer to failure, which occurred on March 28, 2005. The 2005 event nucleated directly on the projection of the 97°E FZ, which divides the earthquake sequence into two distinct slip patches beneath Nias and Simeulue, respectively. The failure regions of the 2005 and 1861 ruptures largely coincide and are limited to the north by the 96°E FZ and to the south by the projection of the IFZ underneath the forearc, which also marks the northern limit of the 1797/1833 rupture zones.

The distinct rupture zones of the 1797/1833, 1861/2004 and 2005 events suggest that tectonic overprint of the margin by subduction of oceanic relief and lithosphere anomalies leads to the formation of first-order segment boundaries on the upper plate that exert a decisive impact on earthquake rupture dynamics. Though the scientific community is beginning to understand the role of segmentation on the extent and distribution of rupture during megathrust events, we still lack the full understanding of the weight and influence of the physical properties of a margin (i.e. pore pressure, material strength, stress distribution) on its seismic potential compared to its structural tectonic heterogeneity. Further analysis of multidisciplinary studies will increasingly close the gap in our ability to assess the impact of different physical-geological parameters on seismotectonic segmentation.

Heidrun Kopp